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A TRANSPORTABLE, MACHINE ORIENTED LIBRARY OF EUROPEAN SKY AND TERRAIN RADIANCE DISTRIBUTIONS WITH CONTEMPORARY RADIOMETRIC AND METEOROLOGICAL PROFILES

Richard W. Johnson
Miriam K. Oleinik

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Scientific Report No. 5
April 1984

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Contract Monitor, Lt.Col. John D. Mill, USAF
Optical Physics Division

Prepared for
Air Force Geophysics Laboratory, Air Force Systems Command
United States Air Force, Hanscom AFB, Massachusetts 01731

UNIVERSITY OF CALIFORNIA SAN DIEGO

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A data set which contains nearly 500 arrays representing the measurements of visible spectrum sky and terrain radiance values first discussed in AFGL-TR-81-0275 has been organized into a readily transportable, machine readable library. A complementary data set including contemporary measurements of atmospheric volume scattering coefficients plus selected meteorological variables as a function of altitude has been included in a similar machine oriented format.

The data base contents are described as are the storage tape formats and sample extraction procedures.

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A TRANSPORTABLE, MACHINE ORIENTED LIBRARY OF EUROPEAN SKY AND TERRAIN RADIANCE DISTRIBUTIONS WITH CONTEMPORARY RAIOMETRIC & METEOROLOGICAL PROFILES

Richard W. Johnson
Miriam K. Oleinik

Visibility Laboratory
University of California, San Diego
Scripps Institution of Oceanography
La Jolla, California 92093

Approved:

Roswell W. Austin, Director
Visibility Laboratory

Approved:

William A. Nierenberg, Director
Scripps Institution of Oceanography

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AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

SUMMARY

A data set which contains nearly 500 arrays representing the measurements of visible spectrum sky and terrain radiance values first discussed in AFGL-TR-81-0275 has been organized into a readily transportable, machine readable library. A complementary data set including contemporary measurements of atmospheric volume scattering coefficients plus selected meteorological variables as a function of altitude has been included in a similar machine oriented format.

The data base contents are described as are the storage tape formats and sample extraction procedures.

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A TRANSPORTABLE, MACHINE ORIENTED LIBRARY OF EUROPEAN SKY AND TERRAIN RADIANCE DISTRIBUTIONS WITH CONTEMPORARY RADIOMETRIC & METEOROLOGICAL PROFILES

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1.0 INTRODUCTION

A substantial body of meteorological and visible spectrum radiometric data describing the optical state of the atmosphere has been collected and reported upon by the Visibility Laboratory of the University of California, San Diego in cooperation with, and under the sponsorship of the Air Force Geophysics Laboratory, Hanscom AFB, Massachusetts. Many of these data are related to the European environment, and are available in hard copy via one or more of the reports listed in Table 1.1, which has been abstracted from AFGL-TR-82-0049, Johnson and Fitch (1981). The OPAQUE measurement program (OPtical Atmospheric QUantities in Europe) was conducted under the auspices of the NATO Research Study Group 8 of Panel IV, AC243.

Table 1.1 OPAQUE related aircraft data reports.

Report No.	Deployment		Data Type
	Series	Date	
AFGL-TR-77-0078	I	Spr. '76	Scatt. Coeff. Profiles & Rel. Meteor.
AFGL-TR-77-0239	II	Fall '76	Scatt. Coeff. Profiles & Rel. Meteor.
AFGL-TR-78-0168	III	Sum. '77	Scatt. Coeff. Profiles & Rel. Meteor.
AFGL-TR-79-0159	IV	Win. '78	Scatt. Coeff. Profiles & Rel. Meteor.
AFGL-TR-80-0207	V	Sum. '78	Scatt. Coeff. Profiles & Rel. Meteor.
AFGL-TR-80-0192	I, II, III	See Above	Aerosol Size Dist. and Analysis
AFGL-TR-81-0154	IV, V	-	Scatt. Coeff. Very Low Alt. Profiles
AFGL-TR-81-0237	I, II, III	-	Scatt. Coeff. Very Low Alt. Profiles
AFGL-TR-81-0275	II, III, V	-	Sky and Terrain Radiances
AFGL-TR-81-0317	I-V	-	Variations in Sky and Terr. Radiances
AFGL-TR-82-0049	IV, V	-	Review of Opt. Prop. & Aerosols

Whereas all but the last two reports listed in Table 1.1 concentrated upon the documentation of the vertical structure of the atmospheric volume scattering coefficient, it is important to note that there is a substantial and valuable complementary data set that is related to the atmospheric radiance distribution. This complementary data set, which is discussed procedurally in Johnson (1981) and analytically in Johnson and Hering (1981), contains angularly precise spectral measurements of the surrounding 4π radiance field as seen by an instrumented aircraft during its traverse of several different flight tracks between the surface and altitudes up to 6 kilometers. The possession of these radiance data in a calibrated and readily retrievable format is what enables one to characterize the broad variety of environmental conditions extant during the flight episodes and thus leads to the development of operationally useful predictive models as in Hering (1981).

These radiance data, in conjunction with their companion scattering coefficient data, are readily applicable to the determination of slant path contrast transmittances,

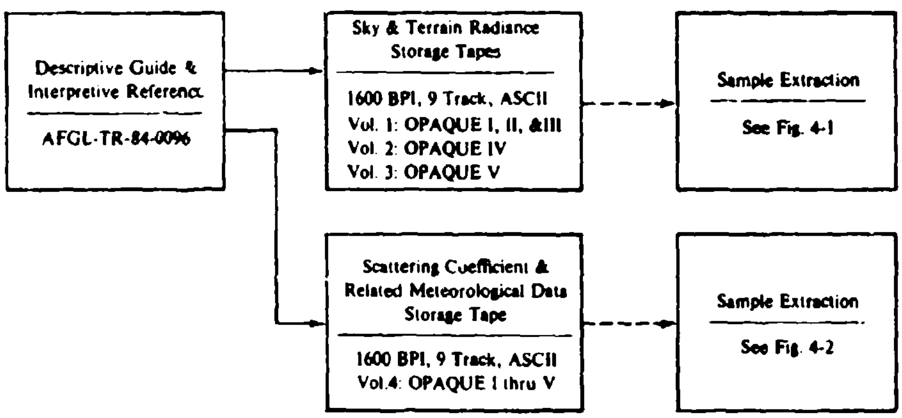

Fig. 1-1. Organizational block diagram.

Table 1.2. Summary of sky and terrain radiance measurements.

FLT NO	DATE	SITE*	FILTER 2 Flight Altitudes (m AGL)				AVAILABLE RADIANCE DATA Spectral Bands (λ, nm)				Total	Storage Volume
			A	B	C	D	478	664	557	765	Arrays	Number
	(1976)											
378	12 May	RB	282	1756	-	-	AB--	AB--	AB--	AB--	16	1
379	17 May	RB	304	1614	3170	6243	ABCD	ABCD	ABCD	A-C-	28	1
	(1976)											
390	25 Oct	RB	286	1514	3006	6079	ABCD	ABCD	ABCD	ABCD	32	1
392	1 Nov	MP	436	1176	-	-	AB--	AB--	AB--	AB--	16	1
393	2 Nov	MP	309	-	-	-	A---	----	----	----	2	1
394	18 Nov	RB	220	943	-	-	AB--	AB--	AB--	AB--	16	1
396	22 Nov	MP	313	-	-	-	A---	A---	A---	A---	8	1
399	3 Dec	BR	673	1592	2832	-	AB--	AB--	ABC	ABC-	20	1
400	4 Dec	BR	691	-	-	-	A---	A---	----	----	[illegible]	1
401	5 Dec	BR	530	1024	2209	5297	ABCD	ABCD	ABCD	ABCD	32	1
402	6 Dec	BR	642	1585	-	4050	AB-D	AB-D	AB-D	AB-D	24	1
	(1977)											1
410	4 Jul	BR	394	1615	3181	-	ABC-	-BC-	ABC-	ABC-	22	1
411	6 Jul	BR	421	1633	2878	-	ABC-	ABC-	ABC-	ABC-	24	1
412	7 Jul	BR	353	1650	2873	-	ABC-	ABC-	----	----	12	1
415	29 Jul	MP	218	848	-	-	AB--	AB--	AB--	AB--	16	1
416	1 Aug	RB	281	1549	3086	4579	ABCD	-BCD	ABC-	ABC-	26	1
419	4 Aug	MP	245	743	-	-	AB--	AB--	AB--	AB--	16	1
421	10 Aug	RB	283	1564	3394	5843	ABCD	ABCD	ABCD	ABCD	32	1
422	11 Aug	RB	333	1569	-	-	AB--	AB--	AB--	AB--	16	1
	(1978)											
431	1 Feb	TR	271	1503	3056	-	ABC-	AB--	----	----	10	2
434	18 Feb	SO	295	1602	3109	6112	ABCD	ABCD	ABCD	AB-D	30	2
435	23 Feb	BK	466	2284	-	-	AB--	AB--	AB--	-B--	14	2
436	23 Feb	BK	435	2099	-	-	AB--	AB--	AB--	AB--	16	2
437	27 Feb	BK	509	1538	3087	5155	ABCD	ABCD	ABCD	ABCD	32	2
438	1 Mar	BK	458	1619	-	-	AB--	AB--	----	----	8	2
439	1 Mar	BK	523	1621	-	-	AB--	AB--	AB--	AB--	16	2
440	2 Mar	BK	517	1664	2877	4095	ABCD	ABCD	ABCD	ABCD	32	2
443	9 Mar	ML	299	926	-	-	AB--	AB--	AB--	AB--	16	2
444	11 Mar	YO	253	714	2171	-	ABC-	ABC-	ABC-	ABC-	24	2
446	15 Mar	YO	207	855	-	-	AB--	AB--	AB--	AB--	16	2
449	18 Mar	YO	257	1029	2454	4595	ABCD	ABCD	A---	A---	20	2
450B	22 Mar	SO	312	1055	-	-	AB--	AB--	AB--	AB--	16	2
454	28 Mar	RB	266	1194	2694	4240	ABCD	ABCD	ABCD	ABCD	32	2
456A	31 Mar	RB	294	886	-	-	AB--	AB--	AB--	AB--	16	2
	(1978)											
462	5 Aug	TR	269	1791	3730	6146	ABCD	AB-D	ABCD	-BCD	28	3
463	7 Aug	TR	276	1819	3674	6083	ABC-	ABCD	ABCD	ABCD	30	3
465	14 Aug	MP	254	1460	-	-	AB--	AB--	AB--	AB--	16	3
466	15 Aug	MP	202	1158	2953	6005	ABCD	ABCD	ABCD	ABC-	30	3
467	18 Aug	SO	250	698	2284	4717	ABCD	ABC-	-BCD	-BCD	26	3
468	21 Aug	MP	263	1349	3103	5850	ABC-	ABCD	ABCD	ABCD	30	3
469	22 Aug	SO	277	747	2475	5838	ABCD	ABCD	ABCD	ABCD	32	3
471	11 Sep	BK	45	535	-	-	AB--	AB--	AB--	AB--	16	3
473	11 Sep	BK	277	852	-	-	AB--	AB--	AB--	AB--	16	3
475	15 Sep	YO	325	933	3070	6135	ABCD	ABCD	AB--	ABC-	26	3
476	16 Sep	YO	324	1008	3085	6150	ABCD	ABCD	ABCD	ABCD	32	3
477	18 Sep	YO	310	623	3481	-	ABC-	ABC-	ABC-	ABC-	24	3
479	26 Sep	RB	307	878	2437	4620	ABCD	ABCD	ABCD	ABCD	32	3

Note: The nominal flight altitudes listed in columns 4 through 7, *i.e.* the altitudes associated with each of the filter 2 measurements, are coded in columns 8 through 11 to designate those altitudes at which additional spectral data are available. Thus for flight 378, the entries "AB--" in columns 8 through 11 indicate that measurements in each of the four spectral bands were made at each of two flight altitudes, A=282m and B=1756m.

*Site Codes: BK - Birkhof, Germany; BR - Bruz, France; ML - Mildenhall, England; MP - Meppen, Germany; RB - Rodby, Denmark; SO - Sigonella, Sicily; SO - Soesterberg, Netherlands; TR - Trapani, Sicily; YO - Yeovilton, England

Table 1.3. Summary of atmospheric vertical profile measurements.

FLT NO	DATE	SITE*	FLIGHT ALTITUDES m(AGL) (1)		AVAILABLE SCAT. COEFF. DATA SPECTRAL BANDS, (λ, nm)				STORAGE VOLUME NUMBER
			MIN	MAX	478	664	557	765	
	(1976)								
378	12 May	RB	270	1800	Y	Y	Y	Y	4
379	17 May	RB	270	6270	Y	Y	Y	Y	4
	(1976)								
390	25 Oct	RB	300	6090	Y	Y	Y	Y	4
400	4 Dec	BR	480	5100	N	Y	Y	Y	4
401	5 Dec	BR	390	5190	Y	Y	Y	Y	4
402	6 Dec	BR	390	3900	N	Y	Y	Y	4
	(1977)								
410	4 Jul	BR	120	3180	Y	Y	Y	Y	4
411	6 Jul	BR	150	2850	Y	Y	Y	Y	4
412	7 Jul	BR	120	5640	Y	Y	Y	Y	4
421	10 Aug	RB	120	5850	Y	Y	Y	Y	4
422	11 Aug	RB	120	1560	Y	Y	Y	Y	4
	(1978)								
431	1 Feb	TR	90	4560	Y	Y	Y	Y	4
435	23 Feb	BK	90	2310	Y	Y	Y	Y	4
436	23 Feb	BK	120	2040	Y	Y	Y	Y	4
437	27 Feb	BK	90	5160	Y	Y	Y	Y	4
439	1 Mar	BK	30	1650	Y	Y	Y	Y	4
444	11 Mar	YO	120	2460	Y	Y	Y	Y	4
446	15 Mar	YO	90	870	Y	Y	Y	Y	4
467	18 Aug	SO	90	4710	Y	Y	Y	Y	4
468	21 Aug	MP	30	6210	Y	Y	Y	Y	4
469	22 Aug	SO	90	5880	Y	Y	Y	Y	4
471	11 Sep	BK	30	540	Y	Y	Y	Y	4
473	11 Sep	BK	30	870	Y	Y	Y	Y	4
475	15 Sep	YO	30	6180	Y	Y	Y	N	4
476	16 Sep	YO	30	6150	Y	Y	Y	Y	4

Meteorological data is included for all flights.

Note: (1) Max-Min altitudes are nominal and coincide with those listed in previously published references. They do not include extrapolations to ground level nor to arbitrary top altitudes.

*Site Codes BK - Birkhof, Germany; BR - Bruz, France; ML - Mildenhall, England; MP - Meppen, Germany; RB - Rodby, Denmark; SG - Sigonella, Sicily; SO - Soesterberg, Netherlands; TR - Trapani, Sicily; YO - Yeovilton, England

atmospheric optical depths, aerosol directional scattering characteristics, flux divergences and their attendant determinations of turbid atmosphere, single scattering albedos.

The description of a transportable, machine oriented data library, shown schematically in Fig. 1-1, containing the sky and terrain radiances summarized in Table 1.2, abstracted from Johnson (1981), and the selected concurrent profile data summarized in Table 1.3, is the subject of this report.

It is important that users of these library data take full advantage of the supplementary detailed information and interpretive guides that are included in the listings of Table 1.1.

2.0 DESCRIPTION OF DATA BASE CONTENT

The tape-oriented data base that is discussed in this report contains two independent but related sets of measurements which are provided on several separate storage tapes whose format will be discussed in the following section. In this section, we will confine ourselves to a brief discussion of the pertinent characteristics of the measured data itself rather than that of the storage medium.

The two data sets comprising this data base are described herein as; a) the Sky and Terrain Radiance Data, and b) the Scattering Coefficient and Related Meteorological Data. For convenience, the Sky and Terrain Radiance Data will often be referred to as the "Scanner" data, and the Scattering Coefficient and Related

Meteorological Data as the "Profile" data. As a general rule, the data is sorted into sub-sets identified by flight number as indicated in Tables 1.2 and 1.3.

As with all of the radiometric data associated with the reports listed in Table 1.1, the radiometric measurements contained in this data library may be characterized by the illustrative information in Fig. 2-1 and Table 2.1. More detailed information regarding the radiometric calibration procedures applied to these data is available in several preceding reports, AFCRL-70-0137, AFCRL-72-0461, and AFGL-TR-80-0207 among others and thus will not be included here.

Users should also be aware that all flight altitudes associated with these data sets are listed in meters above ground level, m(AGL), and have therefore been corrected for local meteorological conditions extant at the time of the measurements.

2.1 Sky and Terrain Radiance Data

As discussed in Johnson (1981) and Johnson and Hering (1981), both of which should be considered companion reports to this current effort, a data set containing nearly 500 arrays representing measurements of sky and terrain radiance values has been developed for general application to image propagation studies within the lower troposphere. The arrays have been organized for storage by flight number primarily, although date and site are also listed in the header information as will be noted in Section 3. As a general rule, the scanner data arrays are organized as illustrated in Table 2.2.

Each of the individual arrays indicated in Table 2.2 contains 1080 data points representing either an upper or lower hemisphere radiance distribution. Each data point represents the apparent radiance of the sky or terrain as "seen" by the 5°FOV of one of the airborne scanning radiometers described in Johnson (1981). There is a data point for every 6° in azimuth and every 5° in zenith angle within each hemisphere. All azimuth notations are taken with respect to the sun as illustrated in Fig. 2-2. It should be noted that for each entry in the data summary listed in Table 1.2, there are two data arrays in the library, one for the upper hemisphere radiances, and one for the simultaneously measured lower hemisphere radiances.

The radiance values included in this data library are the same as those used to create the graphical displays

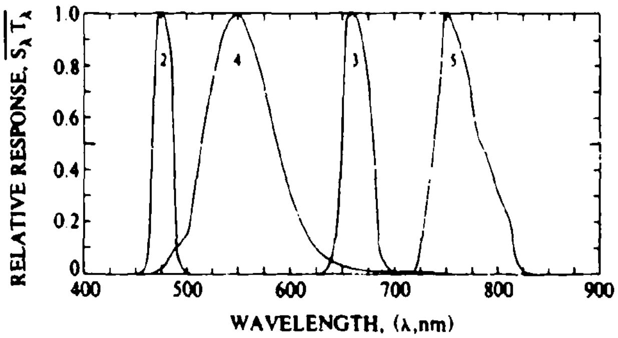

Fig. 2-1 Standard spectral responses. Peak wavelengths are: 2 = 475nm Blue, 3 = 660nm Red, 4 = 550nm Photopic, 5 = 750nm N.I.R.

Table 2.2. Sky & Terrain Radiance Data Organization Per Flight

I. Flight Identification: Flight No., Date, Site, etc.
   A. Altitude Number One (See Table 1.2)
      1. Spectral Band No. 2 (see Fig. 2-1)
         a. Upper Hemisphere Radiance Array
         b. Lower Hemisphere Radiance Array
      2. Spectral Band No. 3
         a. Upper Hemisphere Radiance Array
         b. Lower Hemisphere Radiance Array
      3. Spectral Band No. 4
         a. Upper Hemisphere Radiance Array
         b. Lower Hemisphere Radiance Array
      4. Spectral Band No. 5
         a. Upper Hemisphere Radiance Array
         b. Lower Hemisphere Radiance Array
   B. Altitude Number Two
      1. 2. 3. 4. } *same as in "A" above*
   C. Altitude Number Three
      1. 2. 3. 4. } *same as in "A" above*
   D. Altitude Number Four
      1. 2. 3. 4. } *same as in "A" above*

Table 2.1. Spectral characteristics summary for AVIZ filters.

Spectral Characteristics				Inherent Sun Properties [Johnson (1954)]			Rayleigh Atmosphere Properties (15°C)		
Filter Code No.	Peak Wavelength (nm)	Mean Wavelength (nm)	Effective Passband (nm)	Irradiance ($W/m^2 \mu m$)	Radiance ($W/\Omega m^2 \mu m$) Average	Radiance ($W/\Omega m^2 \mu m$) Center	Attenuation Length (m)	Total Scattering Coefficient (per m)	Vertical Radiance Transmittance
2	475	478	19.9	2.14E+03	3.13E+07	4.07E+07	4.84E+04	2.07E-05	0.839
3	660	664	30.2	1.57E+03	2.30E+07	2.75E+07	1.86E+05	5.41E-06	0.955
4	550	557	78.5	1.90E+03	2.78E+07	3.47E+07	8.93E+04	1.15E-05	0.907
5	750	765	50.4	1.23E+03	1.80E+07	2.10E+07	3.28E+05	3.08E-06	0.974

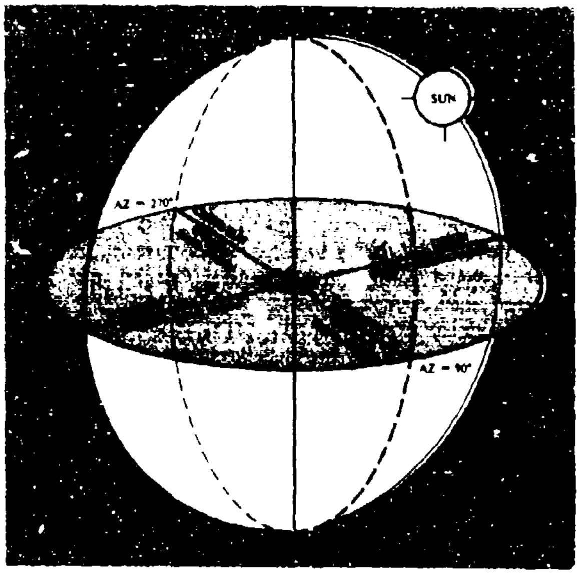

Fig. 2-2. Sky and terrain coordinate system.

Table 2.3. Scattering Coefficient & Related Meteorological Data Organization Per Flight

I. Flight Identification: Flight No., Date, Site, etc.
   A. Profile No. 1 (Ascent) (See Appendix C, Fig. C-1)
      1. Scatt. Coeff. in Spectral Band No. 2 (See Fig. 2-1)
      2. Ambient Temperature
      3. Dewpoint/Frostpoint Temperature
      4. Relative Humidity (computed)
      5. Absolute Pressure
      6. Atmospheric Density (computed)
      7. Real Time
   B. Profile No. 2 (Descent)
      1. Scatt. Coeff. in Spectral Band No. 3
      2. to 7. } *same as in "A" above*
   C. Profile No. 3 (Ascent)
      1. Scatt. Coeff. in Spectral Band 4
      2. to 7. } *same as in "A" above*
   D. Profile No. 4 (Descent)
      1. Scatt. Coeff. in Spectral Band 5
      2. to 7. } *same as in "A" above*

included in Johnson (1981), and Johnson and Hering (1981), and should be used with the same caveats.

THE DATA ARRAYS CONTAINED IN THIS LIBRARY HAVE NOT BEEN CORRECTED FOR THE NEAR SUN STRAY LIGHT EFFECTS AS RECOMMENDED IN SECTION 4 OF JOHNSON (1981), AFGL-TR-81-0275.

An example of the clear day sky and terrain radiance distributions that may be extracted from these data arrays is shown in Appendix A for flight C-379. These graphical displays have been abstracted from Johnson and Hering (1981) as a convenient reference for the reader. The software required to create these displays is not included as part of this report.

2.2 Vertical Profile Data

During each of the data flights listed in Table 1.2, there were radiometric and meteorological measurements conducted at fixed altitudes as well as during ascent and descent modes. The data which were associated with the ascents and descents of the aircraft have been processed and reported in a series of preceding reports which are listed in Table 1.1. However, most of these ascent and descent data, *i.e.* profile data, are also included as part of the general purpose library described herein. These profile data, summarized in Table 1.3, are contained on a separate data tape from the radiance arrays and thus can be conveniently used either with or without the larger radiance data set.

As with the scanner radiance data, these profile data also have been organized for storage by flight number. The data available for each flight is summarized in Table 2.3. Due to a variety of data processing problems, there is not an exact one to one correspondence between the scanner and profile data sets listed in Tables 1.2 and 1.3. The raw data for exact correspondence exists on original storage tapes, but has not been fully retrieved for inclusion in this library.

It should be noted, as discussed in the earlier report series listed in Table 1.1, that the profile measurements were often made over a substantial period of time, and thus represent the spatial and temporal variabilities occurring along a flight track roughly 20 to 30 miles long, over a period of 30 to 120 minutes in time. A brief description of the flight profile used to collect these data has been abstracted from AFGL-TR-80-0207, Johnson and Gordon (1980) and is reproduced as Appendix C.

The radiometric portion of the profile data contains measurements of total volume scattering coefficient as a function of altitude in each of the spectral bands indicated in Table 1.3.

The meteorological portion of the profile data contains measurements of ambient temperature, dewpoint/frostpoint temperature, and absolute pressure. The meteorological measurements were made simultaneously with the radiometric set, and are thus listed in association with a specific spectral band for temporal synchronization, although real time data at one second intervals was also included in the original raw data sets.

In both sets, the specific altitude above ground level has been calculated from measurements of absolute atmospheric pressure, and the mean ground elevation as determined from local navigation charts.

Although the profile data points are all listed at even 30m altitude intervals, users should be aware that the data

values represent the average of several measurements taken throughout that interval. Scattering coefficient measurements were collected at a rate of four samples per second, and meteorological data were collected at a rate of two samples per second during all ascents and descents. The aircrafts average rate of ascent/descent throughout the lower 3 km AGL was approximately 1200 feet per minute (~6 meters/sec).

Also included in the profile data listings are values for several derived quantities. Relative humidity has been calculated from the ambient and dewpoint/frostpoint temperature measurements, and atmospheric density has been calculated from the temperature and pressure measurements.

An example of the measured profile data for flight C-379 is illustrated in Appendix B. These plots of scattering coefficient, ambient temperature and computed relative humidity have been abstracted from AFGL-TR-77-0078, Duntley *et al.* (1977). The software for producing these plots is not included as part of this report.

Users should also note that the profile listings in this library do not include extrapolations above or below the last measured data point. Thus those data points reported in previous reports (Table 1.1) which were parenthetical *i.e.* representing extrapolations, are not present in this data library. Deletions from the original data base for instrumentation reasons are likewise zeroed out, and have not been re-interpolated.

THE DATA LISTINGS CONTAINED IN THIS LIBRARY HAVE NOT BEEN CORRECTED FOR THE HIGH ALTITUDE BIAS INDUCED BY INCOMPLETE AERODYNAMIC PURGING OF THE AIRBORNE INTEGRATING NEPHELOMETER AS DISCUSSED IN SECTION 2.3 OF JOHNSON AND FITCH (1981), AFGL-TR-82-0049.

3.0 DESCRIPTION OF DATA BASE TAPE FORMAT

The primary goals guiding the development of this data library were maximum portability, *i.e.* machine independence and simplicity of retrieval. Consequently, both the tape format and the FORTRAN retrieval codes illustrated in Appendix D and Appendix E have been slanted toward basic simplicity rather than maximum efficiency in data packing and retrieval techniques. Both the "scanner" data and the "profile" data are stored on 9 track tapes at 1600 BPI in standard ASCII notation.

As a convenience to the reader, the title and introductory comment sections from the appendicized retrieval routines have been reproduced as Fig. 3-1 which describes the "scanner" data, and Fig. 3-2 which describes the "profile" data. Whereas the information provided in these figures is generally self-explanatory, a few supplementary remarks may be appropriate.

The description of variable names in Fig. 3-1 includes several which may need clarification. In file one, record one, word 5, "MODE", refers to the flight pattern from which the data were derived. These modes are defined in Appendix C and are used only for extraction validation checks at an earlier level of processing. The same is true of word 6, "IEVENT". This chronological index ties the data array to a specific occurrence in the original in-flight control log. Neither "mode" nor "event number" information is necessary for subsequent applications of these data. Word 11, "IFILTER", identifies the spectral band in which the measurements were made and is defined by the spectral curves shown in Fig. 2-1.

In file two, record one, word 6, "IDENT2", specifies the beginning of the measurement interval for the specific array being listed. The times listed are all in Greenwich Mean Time (GMT). For most of the data contained in this library, the measurement interval for any single array was 180 seconds, during which time, the aircraft was maintaining a straight and level flight altitude at an indicated airspeed of 150 knots. Word 9, "ITYPE" defines an instrumentation set-up which controlled the airborne scanner's azimuthal rate, and thus the overall systems angular precision. For the data in this library, the type code will always be "3" indicating an original azimuthal resolution of 0.6° per data sample which has been averaged to yield one data point every six degrees. Word 13, "ISTRALIT" refers to whether or not the stray light correction procedure recommended in an earlier report, AFGL-TR-81-0275, Johnson (1981) has been implemented. This correction has not been made to the data in this library, and thus all arrays should indicate ISTRALIT=0.

In file two, record four, there are two zenith angle entries associated with each data point, "AVERAGE" and "NOMINAL". As discussed in Johnson (1981) from which Table 3.1 has been abstracted, the airborne scanner's operating pattern called for constant zenith angle setting, *i.e.* "NOMINAL" during each ten second azimuthal revolution. For a variety of electro-mechanical and aerodynamic reasons, this setting was not maintained exactly. The exact zenith angle analog was recorded at a 4 sample/sec rate during each flight, and the average of these actual settings for each revolution is listed in this data library as the "AVERAGE".

A similar, but shorter series of comments is also appropriate to Fig. 3-2 which describes the "profile" data. In the profile data comments, file one, record three, words 4, 5, and 9, MODE, IEVENT, and IFLTR have the same connotation as with the scanner data. However, word 11 "IHIPURGE", refers to an upper altitude correction procedure for only the scattering coefficient data as discussed in Johnson (1981). This correction has not been made to the data in this library, and thus all profile sets should indicate "IHIPURGE"=0.

```
*************************************************************
        SCANNER SKY/TERRAIN DATA

TAPE STRUCTURE
 (1600 BPI, 9 TRACK, ASCII)

FILE 1: (FILE 1 GIVES SUMMARY OF FLIGHTS)
      RECORD 1:(RECORD 1 IS REPEATED 'KFILES' TIMES)
       KFILES....................TOTAL NUMBER OF FILES
       IYR.......................YEAR
       MONTH.....................MONTH
       IDAY......................DAY
       MODE......................MODE IDENTIFICATION
       IEVENT....................EVENT NUMBER
       IHR.......................HOUR
       MIN.......................MINUTES
       ISEC......................SECONDS
       ALT.......................ALTITUDE (METERS AGL)
       IFILTER...................FILTER NUMBER
FORMAT(9I5,F10.0,I5)

      RECORD 2:
       TITLE OF DATA.............FORMAT(80A1)
      RECORD 3:
       FLIGHT NUMBER,DATE,PLACE..FORMAT(80A1)
      RECORD 4:
       GEOGRAPHIC POSITION OF TRACK.....FORMAT(80A1)
      RECORD 5:
       REPORT REFERENCES.........FORMAT(80A1)
EOF

FILE 2:FILE 2 GIVES UPPER HEMISPHERE HEADER ONE,
        HEADER 2,AZIMUTH ANGLES, ZENITH ANGLES,
        SCANNER DATA (REPEATED FOR LOWER HEMISPHERE)

     RECORD 1:
      JHEMIS............HEMISPHERE
      IYR...............YEAR
      MONTH.............MONTH
      IDAY..............DAY
      IEVENT............EVENT NUMBER
      IDENT2............DATA START TIME (HR.MIN.SEC)GMT
      ALT...........ALTITUDE(METERS ABOVE GROUND LEVEL)
      IFLTR.............FILTER NUMBER
      ITYPE.............TYPE CODE
                         (3=SCAN RATE OF 18 REVOLUTIONS
                          AT 10 SEC/REV)
      IAXIS.............AXIS CODE
                         (2=AZIMUTH RELATIVE TO SUN)
      SUNAZ.............SUN AZIMUTH
                         (ANGLE IN DEGREES TRUE)
      SUNZN.............SUN ZENITH
                         (ANGLE IN DEGREES)
      ISTRALIT..........SUN ZONE LIGHT CORRECTION
                         (0=NO,1=YES)
FORMAT(A4,4I2,I7,F7.0,3I2,2F7.1,I2)

     RECORD 2:
      FLIGHT,TRACK NAME,COUNTRY,DATE....FORMAT(81A1)
     RECORD 3:
      IAZIMUTHS......AZIMUTH FROM SUN (60 VALUES)
                     FORMAT(60I4)
     RECORD 4:
      AVERAGE ZENITH ANGLE, NOMINAL ZENITH ANGLE
                     (18 PAIRS OF VALUES)
                     FORMAT(36F6.2)
     RECORD 5 (REPEAT RECORD 5, 60 TIMES)
     SCANNER DATA...............(18 VALUES)
                     FORMAT(18E11.4)

REPEAT RECORDS 1 THRU 5 (OF FILE 2) FOR SECOND HEMISPHERE

EOF

REPEAT FILE 2 FOR 'KFILES' FOR ONE FLIGHT

REPEAT FILE 1 AND FILE 2 FOR EACH FLIGHT

*************************************************************
*
```

Fig. 3-1. Sky and terrain radiance format notes.

```
*************************************************************
SCATTERING COEFFICIENT AND RELATED
      METEOROLOGICAL DATA

TAPE STRUCTURE:

(1600 BPI, 9 TRACK, ASCII)

FILE 1:
      RECORD 1:
        TITLE.........................FORMAT(80A1)
      RECORD 2:
        FLIGHT NUMBER, TRACK ID, DATE....FORMAT(80A1)
      RECORD 3:
        IYEAR...............................YEAR
        MONTH...............................MONTH
        IDAY................................DAY
        MODE................................MODE ID
        IEVENT..............................EVENT NUMBER
        IHOUR...............................HOUR
        MIN.................................MINUTES
        ISEC................................SECONDS
        IFLTR...........................FILTER NUMBER
        NDAT...............TOTAL NUMBER OF DATA RECORDS
        IHIPURGE.......HIGH ALTITUDE PURGE CORRECTION
                 (0=NO,1=YES)

FORMAT(11I5)

    RECORD 4:
        GEOGRAPHIC POSITION................FORMAT (80A1)
    RECORD 5:
        REFERENCE NUMBERS..................FORMAT (80A1)
    RECORD 6: (REPEAT RECORD 6 FOR 'NDAT' RECORDS)
        IALT...................ALTITUDE IN METERS (AGL)
        TEMP...................TEMPERATURE IN DEGREES C
        DEWTEMP................DEWPOINT/FROSTPOINT IN
                                    DEGREES C
        RH.....................RELATIVE HUMIDITY(PERCENT)
        PRESS..................PRESSURE IN MILLIBARS
        DENS...................DENSITY IN KILOGRAMS PER
                                   CUBIC METERS
        SCAT...................SCATTERING COEFFICIENT IN
                                   INVERSE METERS
        ITIME..................TIME (HR.MIN.SEC.)
                                 GREENWICH MEAN TIME (GMT)
FORMAT(I[illegible] 6E11.4,I7)

REPEAT FILE 1 FOR ALL FILTERS
EOF
*************************************************************
*
```

Fig. 3-2. Scattering coefficient and related meteorological, format notes.

Table 3.1. Automatic 2π scanner sweep pattern.

Azimuth Revolution No.	Constant Elevation Angle	Upper Hemisphere Zenith Angle	Lower Hemisphere Zenith Angle
1	2.5°	87.5°	92.5°
2	7.5°	82.5°	97.5°
3	12.5°	77.5°	102.5°
4	17.5°	72.5°	107.5°
5	22.5°	67.5°	112.5°
6	27.5°	62.5°	117.5°
7	32.5°	57.5°	122.5°
8	37.5°	52.5°	127.5°
9	42.5°	47.5°	132.5°
10	47.5°	42.5°	137.5°
11	52.5°	37.5°	142.5°
12	57.5°	32.5°	147.5°
13	62.5°	27.5°	152.5°
14	67.5°	22.5°	157.5°
15	72.5°	17.5°	162.5°
16	77.5°	12.5°	167.5°
17	82.5°	7.5°	172.5°
18	87.5°	2.5°	177.5°

4.0 SAMPLE EXTRACTION PROCEDURE

The data storage tapes referred to in Fig. 1-1 and commented upon in Section 3, can be accessed using the computer routines contained in Appendix D and Appendix E. In keeping with the desire for simplicity, the output produced by these routines is relatively spartan, but for most initial retrievals quite adequate.

An annotated sample of the sky radiance array (UHS) for flight C-378, as produced by program READSCAN is illustrated in Fig. 4-1. Similarly, an annotated sample of the scattering coefficient and related meteorological profile data for flight C-378, as produced by program READPROF, is illustrated in Fig. 4-2.

4.1 Sky & Terrain Radiance Arrays

The following explanatory remarks, directed toward an initially naive user, are related to the sample display of Fig. 4-1, and are complemented by the format notes in Fig. 3-1.

A. This introductory table summarizes all of the radiance array data that is available for any given flight. The entries, defined in file one, record one, of Fig. 3-1, should coincide on a one-to-one basis with the entries in Table 1.2. Users should recall that for every line entry in this introductory table, 4-1A, there will be two data arrays on the storage tape. One upper hemisphere array and one simultaneously measured lower hemisphere array.

B. This two line array identifies the sixty discrete azimuth angles associated with the radiance data which follows. Notice that the array is ordered such that the zero degrees azimuth is with respect to the solar position, and thus for this array is equivalent to 146.7 degrees true, as indicated in the header two lines above.

C. This two line array identifies the eighteen discrete zenith angles associated with the radiance set which follows. Notice that there are two entries in this array for each of the eighteen zenith angle increments in the radiance array; the first being the "AVERAGE" zenith angle, and the second being the "NOMINAL". Note that the listed "NOMINAL" values, 87.50, 82.50, 77.50, etc. are always in accordance with the design specification listed in Table 3.3, but for the reasons mentioned in Section 3, the true average values will vary slightly during any given flight.

D. This two line array represents the first of sixty which contain the actual radiance measurements. Each entry is identified by its corresponding azimuth and zenith angle entry in B and C. Thus, since the radiance data is ordered by increasing azimuth angle, this first group of eighteen radiance points are all at azimuth zero degrees. The second group E, are all at azimuth six degrees, etc. as indicated by the sequence listed in B.

   Within each azimuth group, *i.e.* D or E, etc., the eighteen data points are identified in terms of their zenith angle by the "AVERAGE" entries shown in C.

For example, consider the data point outlined in group E.

a. The radiance value is 0.5594E+03 W/cm^2.
b. The azimuth angle relative to the sun for this data point is 6 degrees; since it is in the second azimuth group as identified in B.
c. The zenith angle for this data point is 33.95 degrees since it is in the fourth position of the second row as identified in C. Note that the equivalent "NOMINAL" value is 27.5 degrees.

A default code, "E+23" will appear as the last four characters in a radiance value to indicate that the radiometer was offscale, beyond its maximum measureable radiance.

4.2 Scattering Coefficient and Related Meteorological Profiles

The following explanatory remarks, also directed toward an initially naive user, are related to the sample display of Fig. 4-2, and are complemented by the format notes in Fig. 3-2.

There are no introductory tables associated with the profile data listings due to the simplicity of the listing. For each flight there will be one profile array for each spectral band in which scattering coefficients were made, as listed in Table 1.3. The appropriate spectral band is identified in each array's header information as shown by the notation, A, in Fig. 4-2.

As illustrated in Fig. 4-2, the profile data is ordered according to altitude as listed in Col I. For each altitude presented, there will be an associated value for each of the parameters shown in Section F of Fig. 3-2, including the time at which the measurements were made.

Thus, for example, consider the row of data points identified by the notation, B.

From Col. I: the altitude of the measurements was 1500m AGL.

From Col. II: the measured value of ambient temperature was 0.7°C.

From Col. IV: the computed value of relative humidity was 92%.

From Col. VII: the measured value of scattering coefficient in filter 2 was 2.6695E-04 m^{-1}, which is reliable to only three significant figures. *i.e.* 2.67E-04 m^{-1}.

From Col. VIII: the time at which the measurements were made was 9 hrs. 59 min. 38 sec. Greenwich Mean Time.

Users should be aware that although the values contained in these listings are recorded to five significant figures, as a formatting convenience, this precision is far beyond that appropriate for the transducers involved. Experimental reliability beyond two or three significant figures is not to be expected.

(A) See text for explanation (File 1, Rec 1 in 3-1)

```
                     8   76   5  12   3   5   9  44  13     282.   2
                     8   76   5  12   3   7   9  49  12     283.   3
                     8   76   5  12   3  14  10   6  15    1756.   2
                     8   76   5  12   3  16  10  12  21    1761.   3
                     8   76   5  12   3  44  10  32  47     272.   4
                     8   76   5  12   3  46  10  37  49     259.   5
                     8   76   5  12   3  53  11   2  38    1445.   4
                     8   76   5  12   3  55  11   7  38    1441.   5
    File 1 Rec 2 —  SKY & TERRAIN RADIANCES IN WATTS/SR(SQ-M)UM
    File 1 Rec 3 —  FLIGHT C-378, RODBYHVN TRACK, DENMARK ON 12 MAY 1976
    File 1 Rec 4 —  TRACK MIDPOINT: 54.68 DEG.N, 11.13 DEG.E
    File 1 Rec 5 —  REPORT REF:AFGL-TR-81-0275, AFGL-TR-81-0317, AFGL-TR-82-0049, AFGL-TR-77-0078
    File 2 Rec 1 —  [redacted]76 512 5   94413    282. 2 3 2  146.7   [redacted] 0
    File 2 Rec 2 —   FOR            FLIGHT C-378 TAKEN AT RODBYHVN TRACK, DENMARK ON 12 MAY 1976
(B) File 2 Rec 3 -   0   6  12  18  24  30  36  42  48  54  60  66  72  78  84  90  96 102 108 114 120 126 132 138 144 150 156 162 168 174
                   180 186 192 198 204 210 216 222 228 234 240 246 252 258 264 270 276 282 288 294 300 306 312 318 324 330 336 342 348 354

(C) File 2 Rec 4 —  87.99  87.50  82.26  82.50  77.97  77.50  72.74  72.50  68.60  67.50  63.93  62.50  57.98  57.50  52.28  52.50  53.25  47.50
                    47.76  42.50  43.86  37.50  39.04  32.50  [redacted]  28.46  22.50  24.15  17.50  19.39  12.50  13.88   7.50   9.58   2.50

(D) File 2 Rec 5 —  0.1947E+03 0.2363E+03 0.2570E+03 0.2858E+03 0.3018E+03 0.3267E+03 0.3131E+03 0.9931E+02 0.8167E+02
                    0.4521E+03 0.9228E+03 0.1291E+04 0.6239E+03 0.6065E+03 0.1502E+03 0.3851E+03 0.3475E+03 0.3036E+03

(E) ————————        0.2028E+03 0.2383E+03 0.2724E+03 0.2823E+03 0.2919E+03 0.3306E+03 0.3116E+03 0.9931E+02 0.8159E+02
                    0.4000E+03 0.6295E+03 0.6021E+03 [redacted] 0.5771E+03 0.1502E+03 0.3911E+03 0.3502E+03 0.3009E+03

                    0.2002E+03 0.2396E+03 0.2834E+03 0.2836E+03 0.2928E+03 0.2934E+03 0.3101E+03 0.9931E+02 0.8152E+02
                    0.3519E+03 0.5083E+03 0.4436E+03 0.5102E+03 0.5483E+03 0.1502E+03 0.4115E+03 0.3406E+03 0.2901E+03

                    0.1963E+03 0.2328E+03 0.2669E+03 0.2841E+03 0.2910E+03 0.2981E+03 0.2981E+03 0.9931E+02 0.8144E+02
                    0.3175E+03 0.4238E+03 0.4045E+03 0.4785E+03 0.5086E+03 0.1502E+03 0.3918E+03 0.3045E+03 0.2715E+03

                    0.1926E+03 0.2281E+03 0.2506E+03 0.2469E+03 0.2659E+03 0.2988E+03 0.2928E+03 0.9931E+02 0.8136E+02
                    0.3267E+03 0.3421E+03 0.3845E+03 0.3900E+03 0.4653E+03 0.1502E+03 0.3845E+03 0.2736E+03 0.2503E+03

                    0.1893E+03 0.2164E+03 0.2352E+03 0.2300E+03 0.2174E+03 0.2707E+03 0.2914E+03 0.9931E+02 0.8129E+02
                    0.2981E+03 0.3009E+03 0.3609E+03 0.3584E+03 0.4215E+03 0.1502E+03 0.3563E+03 0.2663E+03 0.2321E+03

                    0.1734E+03 0.2108E+03 0.2116E+03 0.2076E+03 0.2054E+03 0.2342E+03 0.2460E+03 0.9931E+02 0.8121E+02
                    0.2649E+03 0.2981E+03 0.3150E+03 0.3453E+03 0.3827E+03 0.1502E+03 0.3142E+03 0.2605E+03 0.2216E+03

                    0.1632E+03 0.2042E+03 0.2036E+03 0.1901E+03 0.1741E+03 0.1960E+03 0.2342E+03 0.9931E+02 0.8113E+02
                    0.2485E+03 0.2629E+03 0.2757E+03 0.3432E+03 0.3283E+03 0.1502E+03 0.2982E+03 0.2464E+03 0.2207E+03
```

Fig. 4-1. Annotated sample output: Sky Radiance.

```
 1 F1.1.D!!
 SCATTERING COEFFICIENT AND RELATED METEOROLOGICAL DATA                      — File 1 Rec 1
**        FLIGHT C-378 TAKEN AT RODBYHVN TRACK, DENMARK ON 12 MAY 1976        — File 1 Rec 2
  76    5   12    7   11    9   56   28   [redacted]   52    0 (A)              — File 1 Rec 3
 TRACK MIDPOINT: 54.68 DEG.N, 11.13 DEG.E                                     — File 1 Rec 4
 REPORT REF:AFGL-TR-81-0275, AFGL-TR-81-0317, AFGL-TR-82-0049, AFGL-TR-77-0239
File 1 Rec 6— 1800-3.2031E-01-2.3170E+00 7.7636E+01 8.1012E+02 1.0344E+00 6.2584E-05 100034
 1770-4.1518E-01-1.7927E+00 8.8217E+01 8.1374E+02 1.0394E+00 6.0693E-05 100027
 1740-1.7614E-01-2.8922E+00 7.9605E+01 8.1734E+02 1.0431E+00 6.1627E-05 100023
 1710 7.6923E-02-3.7502E+00 7.2685E+01 8.1995E+02 1.0455E+00 6.4216E-05 100020
 1680 9.2308E-02-7.4510E+00 5.2874E+01 8.2121E+02 1.0470E+00 6.9992E-05 100012
 1650 4.6154E-02-7.9118E+00 5.0937E+01 8.2445E+02 1.0513E+00 7.5563E-05 100002
 1620 4.6154E-02-5.4902E+00 6.2869E+01 8.2947E+02 1.0577E+00 1.0526E-04 100001
 1590 5.9341E-02-2.6190E+00 8.0122E+01 8.3070E+02 1.0592E+00 1.4730E-04  95954
 1560 1.8462E-02-6.8627E-01 9.4418E+01 8.3470E+02 1.0645E+00 1.6434E-04  95949
 1530 2.2500E-01-6.3725E-01 9.3361E+01 8.3846E+02 1.0685E+00 2.1804E-04  95941
(B)—1500 7.0769E-01-3.9216E-01 9.1993E+01 8.4082E+02 1.0696E+00 2.6695E-04  95938
 1470 6.9231E-01 0.0000E+00 9.5048E+01 8.4495E+02 1.0749E+00 2.8872E-04  95937
 1440 9.3462E-01-2.3084E-01 9.1724E+01 8.4641E+02 1.0758E+00 2.9221E-04  95929
 1410 1.0892E+00-1.3405E-01 9.1412E+01 8.5018E+02 1.0800E+00 2.9105E-04  95924
 1380 1.4000E+00-4.2484E-01 8.7278E+01 8.5298E+02 1.0823E+00 3.0124E-04  95921
 1350 1.5323E+00 8.5634E-02 9.0050E+01 8.5644E+02 1.0862E+00 3.0736E-04  95916
 1320 1.7407E+00 3.3156E-02 8.8380E+01 8.6082E+02 1.0909E+00 2.9664E-04  95909
 1290 1.9077E+00-3.5948E-01 8.4641E+01 8.6261E+02 1.0925E+00 2.6886E-04  95906
 1260 2.2879E+00-2.8954E-01 8.2820E+01 8.6574E+02 1.0950E+00 2.7439E-04  95859
 1230 2.8154E+00 8.1633E-01 8.6667E+01 8.6972E+02 1.0979E+00 2.8871E-04  95858
 1200 2.9641E+00 5.4422E-01 8.4129E+01 8.7251E+02 1.1008E+00 2.9564E-04  95849
 1170 3.5723E+00 2.8571E-01 7.9048E+01 8.7570E+02 1.1024E+00 2.9169E-04  95844
```

I	II	III	IV	V	VI	VII	VIII
Alt. m AGL	Temp. (°C)	Dewpoint Temp. (°C)	Relative Humidity (%)	Atmos. Pressure (mb)	Atmos. Density (Kg/m^3)	Scatt. Coeff. (m^{-1})	Time GMT

Fig. 4-2. Annotated sample output: Scattering coefficient & related meteorological data.

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Johnson, R.W. and B.W. Fitch (1981), "A Review of Measured Atmospheric Optical Properties and Their Contemporary Aerosol Size Distributions," SIO Ref. 82-22, AFGL-TR-82-0049, NTIS No. ADA 123 940, University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory.

Johnson, R.W. (1981), "Airborne Measurements of European Sky and Terrain Radiances," SIO Ref. 82-2, AFGL-TR-81-0275, NTIS No. ADA 114 637, University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory.

Johnson, R.W. and W.S. Hering (1982), "An Analysis of Natural Variations In European Sky and Terrain Radiance Measurements," SIO Ref. 82-6, AFGL-TR-81-0317, NTIS No. ADA 120 487, University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory.

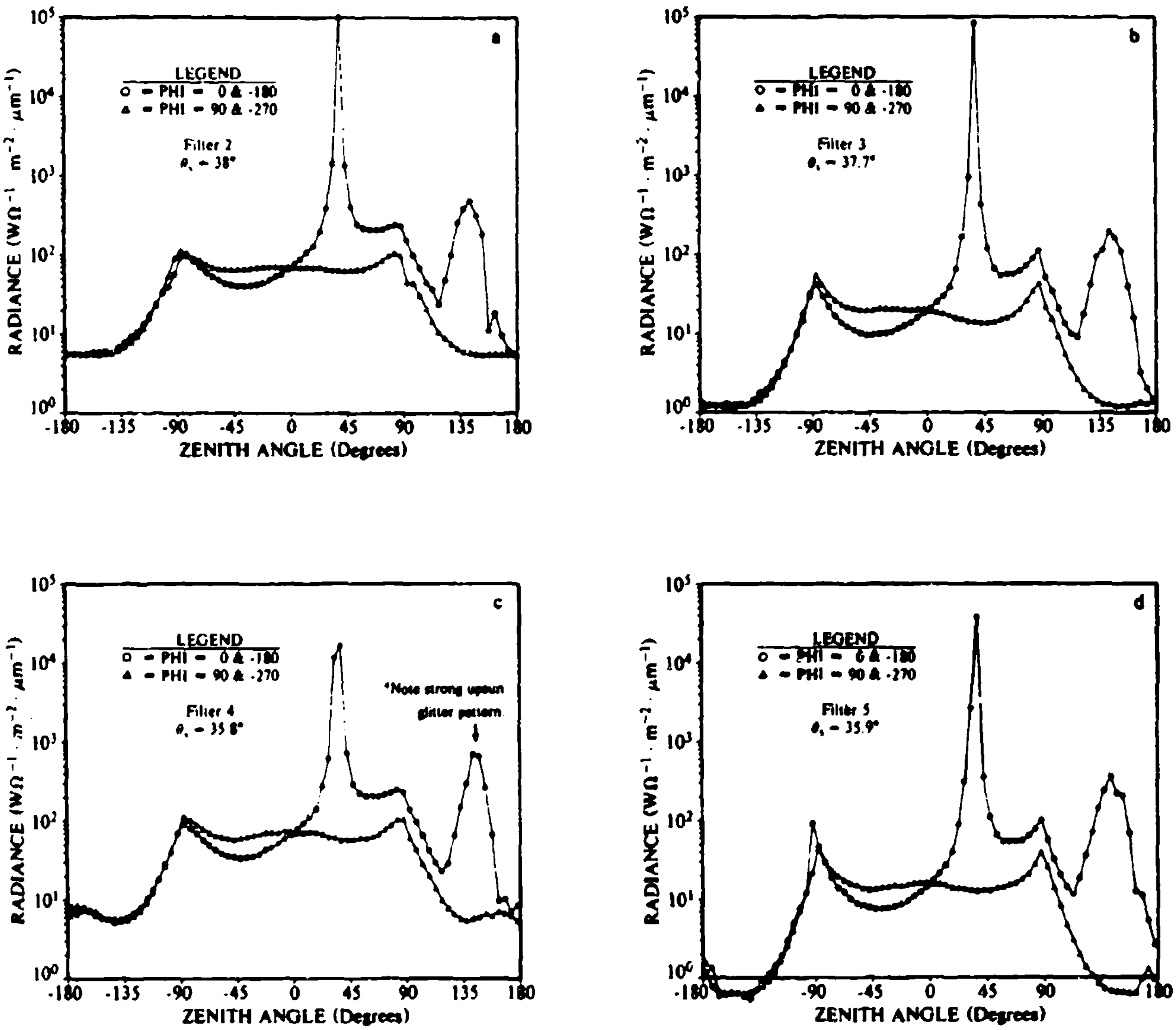

Fig. A-1. Flight C-379 (Rodby, Denmark), clear sky over ocean with glitter, 300 m AGL. (Fig. 3-7 from AFGL-TR-81-0317)

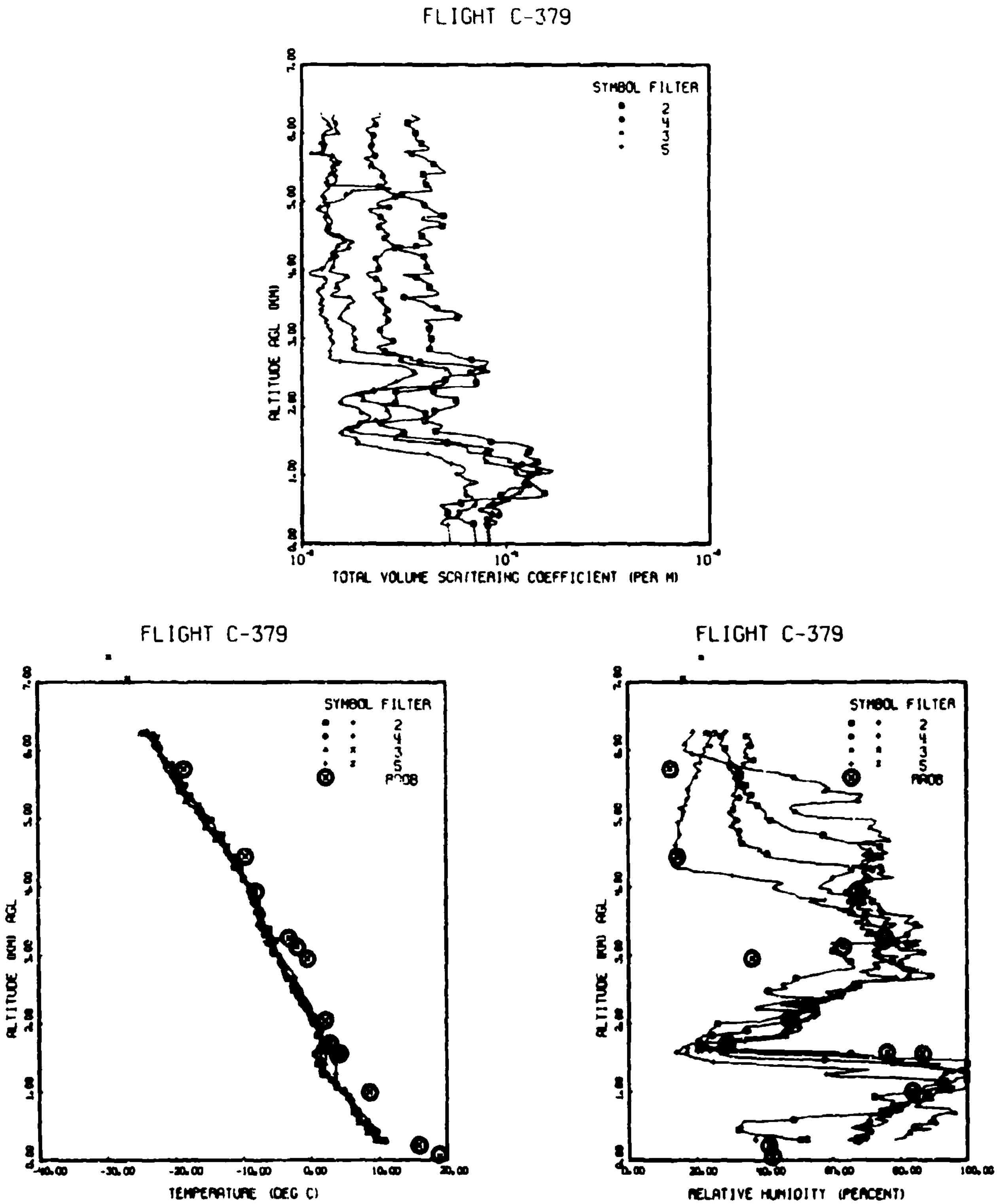

Fig. B-1. Scattering coefficient & related meteorological data for flight C-379. (Abstracted from sections 6 & 7 in AFGL-TR-77-0078)

APPENDIX C

FLIGHT PROFILE SUMMARY

AIRBORNE SYSTEM

The data collection sequence for the airborne system was broken into five standardized elements: (1) preflight warmup and calibration check, (2) straight and level sequences, (3) vertical profile sequences, (4) in-flight calibration checks, and (5) post-flight calibration check.

An illustration of the typical flight pattern, which was used for most flights, is shown in Fig. C-1. In this stylized pattern, two basic elements, the straight and level (ST&LV) and the vertical profile (V-PRO), were combined to yield the total mission flight plan. A description of these two pattern elements and the calibration elements is detailed in AFCRL-72-0255, Duntley *et al.* (1972a), modified in AFCRL-TR-75-0457, Duntley *et al.* (1975b), and summarized in the following paragraphs.

1. Straight and Level runs (ST&LV), Mode 03 - The ST&LV runs were primarily 2π scanner runs. The measurement of upper and lower hemisphere radiance distributions had top priority. One sky mode scanner pattern (192 seconds) plus one sun mode scanner pattern (64 seconds) were run at each altitude with each of two optical filters.

   "Sky Mode" and "Sun Mode" refer to procedural adjustments which were made to enable radiometric measurements of acceptable fidelity in the high gradient regions of the solar aureole. In "Sky Mode" configuration, radiometric sensitivity was adjusted to optimize measurement of sky radiances far removed, *e.g.* $>30°$, from the solar disc. Conversely, in "Sun Mode", sensitivity was reduced to enable direct solar disc and aureole measurements at the expense of the off-sun regions.

   During ST&LV runs the aircraft maintained a fixed heading, a constant indicated airspeed of 150 knots or less, and a 2.5 degree nose-high flight altitude.

2. Vertical Profile runs (V-PRO), Mode 07 - The V-PRO runs were primarily integrating nephelometer and variable path function meter runs. The measurement of the total scattering coefficient profile had top priority. Second priority was measurement of the vertical path function profile. Each V-PRO ascent or descent was made using a single filter.

   During the V-PRO runs the aircraft maintained a fixed heading, with the sun off the left wingtip, and a flight attitude not exceeding 4 degrees nose down or 8 degrees nose up. An average rate of climb or descent of 1200 feet/minute was optimum, and airspeed was not critical, but remained constant once established.

3. Cross-Calibration Climbs (X-CAL), Mode 08 - The X-CAL climbs were specifically designed to validate the performance of the UHS, LHS, and ERT radiometer systems. The simultaneous measurement of a common uniform segment of sky by these three radiometers had top priority. Two X-CAL climbs were associated with each standard profile, one preceding the first ST&LV run and the second following the last ST&LV run. Both sky mode and sun mode measurements were made with the UHS system.

   During the 4-minute X-CAL climb the aircraft maintained a fixed heading, with the sun in the aft hemisphere, and a 5-degree nose-high flight attitude. The aircraft was flown directly toward the clearest and most uniform portion of the sky as was practical.

4. Calibration Blocks (A/D CAL), Mode 00, M-CAL, Mode 01, N-CAL, Mode 09 - The 32-second blocks of calibration data were inserted periodically throughout the entire data mission. They were designed to provide calibration update information to the post-flight computer processing sequences. There are 21 assorted calibration blocks associated with each standard profile.

   During these calibration blocks there were no project-imposed requirements upon aircraft speed or attitude.

GENERAL FLIGHT PATTERN

In this profile, ST&LV data runs were made using two different spectral filters at each of four altitudes. The ascent V-PRO was made using the first of the two filters, and the descent V-PRO was made using the second. After the descent V-PRO, the entire sequence was repeated using a second pair of filters.

The idealized flight profile would result in all ground tracks falling on a single line running between the Initial Point (I.P.) and the Turning Point (T.P.). In practice, the ST&LV elements were actually stacked in a slab of atmosphere approximately 30 miles (48 km) long, 0.5 mile (0.8 km) wide, and 4 miles (6.4 km) high.

Periodically, in response to specialized data requirements or weather conditions, supplementary flight patterns were added to the mission profile. For example, a pattern made up of a (2+3) profile, *i.e.*, two spectral filters at each of three altitudes was used as was a (2+2) profile, *i.e.*, two spectral filters at each of two altitudes. Both the (2+3) and (2+2) profiles are generally considered low to medium altitude profiles, and were normally used on flights performed under a full overcast or low to intermediate level cloud decks. Three flights consisted of V-PRO climb outs, supplemented with only directional scattering measurements at the minimum and maximum altitudes.

At the conclusion of each mission, the radiometric data which were recorded and stored on magnetic tape were returned to the Visibility Laboratory for computer reduction and analysis.

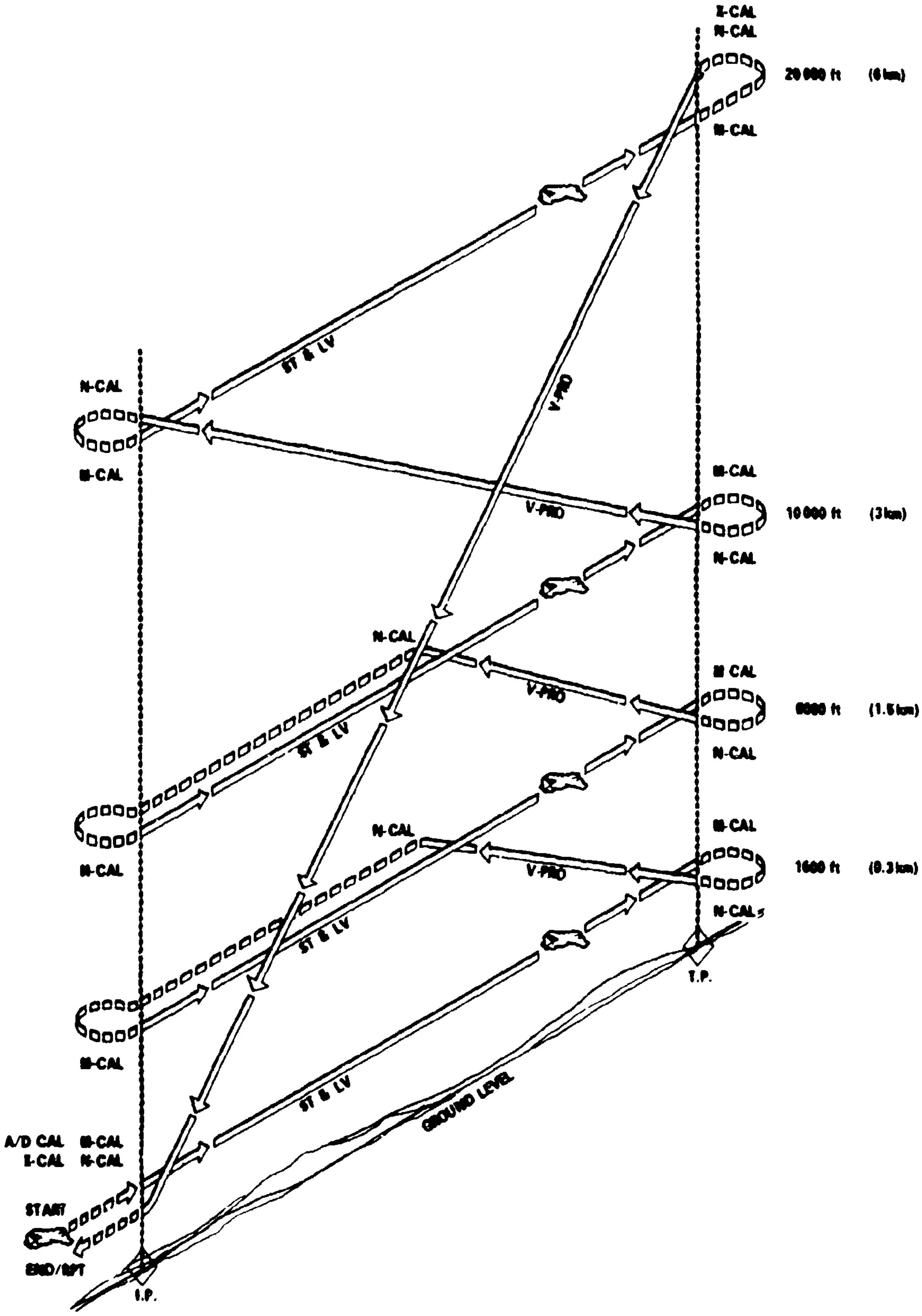

Fig. C-1. Typical Visibility Laboratory Flight Profile.
(Fig. 4-1 from AFGL-TR-80-0207)

APPENDIX D

```
C*************************************************************
C       TITLE:
C        READSCAN.............FORTRAN PROGRAM
C*************************************************************
C       PURPOSE:
C        READ SCANNER TRANSMITTAL TAPE OF SUN/TERRAIN DATA
C*************************************************************
C                SCANNER SKY/TERRAIN DATA
C
C       TAPE STRUCTURE
C        (1600 BPI, 9 TRACK, ASCII)
C        (ALL RECORDS = 240 BYTES)
C
C       FILE 1: (FILE 1 GIVES SUMMARY OF FLIGHTS)
C             RECORD 1:(RECORD 1 IS REPEATED 'KFILES' TIMES)
C              KFILES....................TOTAL NUMBER OF FILES
C              IYR.......................YEAR
C              MONTH.....................MONTH
C              IDAY......................DAY
C              MODE......................MODE IDENTIFICATION
C              IEVENT....................EVENT NUMBER
C              IHR.......................HOUR
C              MIN.......................MINUTES
C              ISEC......................SECONDS
C              ALT.......................ALTITUDE (METERS AGL)
C              IFILTER...................FILTER NUMBER
C       FORMAT(9I5,F10.0,I5)
C
C             RECORD 2:
C              TITLE OF DATA.............FORMAT(80A1)
C             RECORD 3:
C              FLIGHT NUMBER,DATE,PLACE..FORMAT(80A1)
C             RECORD 4:
C              GEOGRAPHIC POSITION OF TRACK.....FORMAT(80A1)
C             RECORD 5:
C              REPORT REFERENCES.........FORMAT(80A1)
C       EOF
C
C       FILE 2:FILE 2 GIVES UPPER HEMISPHERE HEADER ONE,
C               HEADER 2,AZIMUTH ANGLES, ZENITH ANGLES,
C               SCANNER DATA (REPEATED FOR LOWER HEMISPHERE)
C
C            RECORD 1:
C             JHEMIS............HEMISPHERE
C             IYR...............YEAR
C             MONTH.............MONTH
C             IDAY..............DAY
C             IEVENT............EVENT NUMBER
C             IDENT2.............DATA START TIME (HR.MIN.SEC)GMT
C             ALT...........ALTITUDE(METERS ABOVE GROUND LEVEL)
C             IFLTR.............FILTER NUMBER
C             ITYPE.............TYPE CODE
C                                (3=SCAN RATE OF 18 REVOLUTIONS
C                                 AT 10 SEC/REV)
C             IAXIS.............AXIS CODE
C                                (2=AZIMUTH RELATIVE TO SUN)
```

```
C           SUNAZ.............SUN AZIMUTH
C                             (ANGLE IN DEGREES TRUE)
C           SUNZN.............SUN ZENITH
C                             (ANGLE IN DEGREES)
C           ISTRALIT..........SUN ZONE LIGHT CORRECTION
C                             (0=NO,1=YES)
C      FORMAT(A4,4I2,I7,F7.0,3I2,2F7.1,I2)
C
C          RECORD 2:
C           FLIGHT,TRACK NAME,COUNTRY,DATE....FORMAT(81A1)
C          RECORD 3:
C           IAZIMUTHS......AZIMUTH FROM SUN (60 VALUES)
C                         FORMAT(60I4)
C          RECORD 4:
C           AVERAGE ZENITH ANGLE, NOMINAL ZENITH ANGLE
C                         (18 PAIRS OF VALUES)
C                         FORMAT(36F6.2)
C          RECORD 5 (REPEAT RECORD 5, 60 TIMES)
C          SCANNER DATA..............(18 VALUES)
C                         FORMAT(18E11.4)
C
C      REPEAT RECORDS 1 THRU 5 (OF FILE 2) FOR SECOND HEMISPHERE
C
C      EOF
C
C      REPEAT FILE 2 FOR 'KFILES' FOR ONE FLIGHT
C
C      REPEAT FILE 1 AND FILE 2 FOR EACH FLIGHT
C**********************************************************
C      PROGRAMMER
C      MIRIAM K. OLEINIK
C      VISIBILITY LABORATORY
C      SCRIPPS INSTITUTION OF OCEANOGRAPHY
C      UNIVERSITY OF CALIFORNIA SAN DIEGO
C**********************************************************
C      **** NOTE ****
C      TAPE INPUT FUNCTIONS ARE COMPUTER SYSTEMS DEPENDENT
C
C***********************************************************
      DIMENSION ZA(18),ZN(18),IAZIMUTH(60),ITITLE(240),
     1 DATA (18), JERROR(240)
      DATA NFLIGHT/1/
      DATA LUW/6/
C
C       NFLIGHT = TOTAL FLIGHTS TO READ
C       LUW = LOGICAL UNIT FOR OUTPUT PRINTER
C
C
C        LUTAP1 IS LOGICAL UNIT OF ID RECORDS
C        LUTAPE IS LOGICAL UNIT OF DATA RECORDS
C
        LUTAP1=80
        LUTAPE=60
C       LOOP FOR TOTAL FLIGHTS
C
      DO 4000 IFLIGHT = 1,NFLIGHT
```

```
C
C       OPEN FILE FOR ID RECORDS
C
        OPEN(UNIT=LUTAP1,RECORDSIZE=240,TYPE='OLD')
C
C       READ IDENTIFICATION RECORD (1)
C
        IFILE = 1
  100   FORMAT(9I5,F10.0,I5)
  200   CONTINUE
        READ(LUTAP1,100,ERR=320)KFILES,IYR,MONTH,IDAY,MODE,
     1  IEVENT,IHR,MIN,ISEC,ALT,IFILTER
        IFILE = IFILE + 1
        WRITE(LUW,300)KFILES,IYR,MONTH,IDAY,MODE,IEVENT,IHR,
     1  MIN,ISEC,ALT,IFILTER
  300   FORMAT(1X,9I5,F10.0,I5)
        GO TO 340
C
C       ERROR IN READ, READ IN ALPHA AND PRINT
C
  320   WRITE(LUW,7010)
        BACKSPACE LUTAP1
        READ(LUTAP1,970)(JERROR(JA),JA=1,60)
        WRITE(LUW,550)(JERROR(JA),JA=1,60)
C
C       TEST IF END OF ID RECORD (1) READ
C
  340   IF(IFILE.GT.KFILES)GO TO 400
C       GO READ NEXT ID RECORD
        GO TO 200
  400   CONTINUE
C
C       READ IDENTIFICATION RECORD (2)
C
         DO 600 IHEAD = 1,4
         READ(LUTAP1,500)(ITITLE(JA),JA=1,80)
  500    FORMAT(240A1)
  550    FORMAT(3(1X,80A1/))
  600    WRITE(LUW,550)(ITITLE(JA),JA=1,80)
C
C        LOOP FOR TOTAL FILES THIS FLIGHT
C
          DO 3000 IFILE = 1, KFILES
C
C         OPEN FILE FOR DATA RECORDS
C
          OPEN(UNIT=LUTAPE,RECORDSIZE=240,TYPE='OLD')
C
C         LOOP FOR 2 HEMISPHERES (UPPER AND LOWER)
C
           DO 2000 IHEMIS = 1,2
C
C          READ SCANNER HEADER (1)
C
```

```
      READ(LUTAPE,700,ERR=740)JHEMIS,IYR,MONTH,IDAY,IEVENT,
     1 IDENT2,ALT,IFLTR,ITYPE,IAXIS,SUNAZ,SUNZN,ISTRALIT
  700 FORMAT(1X,A3,4I2,I7,F7.0,3I2,2F7.1,I2)
      WRITE(LUW,700)JHEMIS,IYR,MONTH,IDAY,IEVENT,IDENT2,
     1 ALT,IFLTR,ITYPE,IAXIS,SUNAZ,SUNZN,ISTRALIT
      GO TO 750
C
C     ERROR IN TAPE READ, READ IN ALPHA AND PRINT
C
  740 WRITE(LUW,7010)
      BACKSPACE LUTAPE
      READ(LUTAPE,970)(JERROR(JA),JA=1,51)
      WRITE(LUW,550)(JERROR(JA),JA=1,51)
C
C     READ SCANNER HEADER (2)
C
  750 READ(LUTAPE,500)(ITITLE(JA),JA=1,81)
      WRITE(LUW,500)(ITITLE(JA),JA=1,81)
C
C     AZIMUTHS
C
      READ(LUTAPE,800,ERR=845)(IAZIMUTH(JA),JA=1,60)
  800 FORMAT(60I4)
      WRITE(LUW,840)(IAZIMUTH(JA),JA=1,60)
  840 FORMAT(2(30I4/))
      GO TO 850
C
C     ERROR IN TAPE INPUT, READ IN ALPHA AND PRINT
C
  845 WRITE(LUW,7010)
      BACKSPACE LUTAPE
      READ(LUTAPE,970)(JERROR(JA),JA=1,240)
      WRITE(LUW,550)(JERROR(JA),JA=1,240)
C
C     ZENITHS
C
  850 READ(LUTAPE,855,ERR=865)(ZA(JA),ZN(JA),JA=1,18)
  855 FORMAT(36F6.2)
      WRITE(LUW,860)(ZA(JA),ZN(JA),JA=1,18)
  860 FORMAT(2(18F7.2/))
      GO TO 890
  865 WRITE(LUW,7010)
      BACKSPACE LUTAPE
      READ(LUTAPE,970)(JERROR(JA),JA=1,216)
      WRITE(LUW,550)(JERROR(JA),JA=1,216)
  890 CONTINUE
C
C     LOOP FOR SCANNER DATA
C
        DO 1000 IDATA = 1,60
        READ(LUTAPE,900,ERR=960)(DATA(JA),JA=1,18)
  900   FORMAT(18E11.4)
        WRITE(LUW,910)(DATA(JA),JA=1,18)
  910   FORMAT(2(1X,9E11.4/))
        GO TO 1000
```

```
C
C       ERROR IN TAPE READ, READ IN ALPHA AND PRINT
C
  960       WRITE(LUW,7010)
            BACKSPACE LUTAPE
            READ(LUTAPE,970)(JERROR(JA),JA=1,198)
  970       FORMAT(240A1)
            WRITE(LUW,550)(JERROR(JA),JA=1,198)
C
 1000       CONTINUE
C
C           GO READ LOWER HEMISPHERE
C
 2000       CONTINUE
C
C          CLOSE AND SAVE DATA FILE
C
         CLOSE(UNIT=LUTAPE,DISPOSE='SAVE')
         LUTAPE=LUTAPE+1
C
C        GO READ NEXT FILE THIS FLIGHT
C
 3000   CONTINUE
C
C       CLOSE AND SAVE HEADER RECORDS
C
        CLOSE(UNIT=LUTAP1,DISPOSE='SAVE')
        LUTAP1=LUTAP1+1
C
C       GO READ NEXT FLIGHT
C
 4000 CONTINUE
C
C       ERROR BRANCH MESSAGE
C
 7010 FORMAT(1X, ' ****  ERROR IN TAPE READ; READ IN ALPHA AND PRINT ')
 9000 CONTINUE
      END
$
```

```
C***************************************************
C       TITLE
C        READPROF.FOR
C****************************************************
C       PURPOSE
C        READ SCATTERING COEFFICIENT AND RELATED
C        METEOROLOGICAL DATA
C        (TRANSMITTAL TAPE DATA)
C*****************************************************
C       SCATTERING COEFFICIENT AND RELATED
C              METEOROLOGICAL DATA
C
C       TAPE STRUCTURE:
C
C       (1600 BPI, 9 TRACK, ASCII)
C       (ALL RECORDS=80 BYTES)
C
C       FILE 1:
C              RECORD 1:
C                  TITLE......................... FORMAT(80A1)
C              RECORD 2:
C                  FLIGHT NUMBER, TRACK ID, DATE....FORMAT(80A1)
C              RECORD 3:
C                  IYEAR................................YEAR
C                  MONTH................................MONTH
C                  IDAY.................................DAY
C                  MODE.................................MODE ID
C                  IEVENT...............................EVENT NUMBER
C                  IHOUR................................HOUR
C                  MIN..................................MINUTES
C                  ISEC.................................SECONDS
C                  IFLTR..............................FILTER NUMBER
C                  NDAT...............TOTAL NUMBER OF DATA RECORDS
C                  IHIPURGE.......HIGH ALTITUDE PURGE CORRECTION
C                          (0=NO,1=YES)
C
C       FORMAT(11I5)
C
C            RECORD 4:
C                  GEOGRAPHIC POSITION................FORMAT (80A1)
C            RECORD 5:
C                  REFERENCE NUMBERS..................FORMAT (80A1)
C            RECORD 6: (REPEAT RECORD 6 FOR 'NDAT' RECORDS)
C                  IALT..................ALTITUDE IN METERS (AGL)
C                  TEMP..................TEMPERATURE IN DEGREES C
C                  DEWTEMP...............DEWPOINT/FROSTPOINT IN
C                                           DEGREES C
C                  RH....................RELATIVE HUMIDITY(PERCENT)
C                  PRESS.................PRESSURE IN MILLIBARS
C                  DENS..................DENSITY IN KILOGRAMS PER
C                                          CUBIC METERS
C                  SCAT..................SCATTERING COEFFICIENT IN
C                                          INVERSE METERS
C                  ITIME.................TIME (HR.MIN.SEC.)
C                                            GREENWICH MEAN TIME (GMT)
```

```
C       FORMAT(I5,6E11.4,I7)
C
C       REPEAT FILE 1 FOR ALL FILTERS
C       EOF
C*******************************************************************
C       PROGRAMMER
C       MIRIAM K. OLEINIK
C       VISIBILITY LABORATORY
C       SCRIPPS INSTITUTION OF OCEANOGRAPHY
C       UNIVERSITY OF CALIFORNIA SAN DIEGO
C**************************************************************
C       **** NOTE ****
C       TAPE INPUT FUNCTIONS ARE COMPUTER SYSTEMS DEPENDENT
C*****************************************************************
C
        DIMENSION DATA(6),ITITLE(80)
        DIMENSION IPOS(80),IREF(80)
        DATA LUW/6/
C
C       LUW = LOGICAL UNIT FOR PRINTER
C      LUTAPE = LOGICAL UNIT FOR INPUT FROM TAPE
       LUTAPE = 60
C
   40 FORMAT(80A1)
C       OPEN INPUT DISK FILE
C
       OPEN(UNIT=LUTAPE,RECORDSIZE=80, TYPE='OLD')
C
C
C       LOOP FOR ALL FILTERS
C
   60 CONTINUE
C
C       READ PROFILE DATA
C
C       INPUT  TAPE HEADER INFORMATION
C
       READ(LUTAPE,40,END=3000)(ITITLE(JA),JA=1,80)
       WRITE(LUW,40)(ITITLE(JA),JA=1,80)
       READ(LUTAPE,40,END=3000)(ITITLE(JA),JA=1,80)
       WRITE(LUW,40)(ITITLE(JA),JA=1,80)
       READ(LUTAPE,100,END=3000)IYEAR,MONTH,IDAY,MODE,IEVENT,
      1 IHOUR,MIN,ISEC,IFLTR,NDAT,IHIPURGE
  100 FORMAT(11I5)
       WRITE(LUW,100)IYEAR,MONTH,IDAY,MODE,IEVENT,
      1 IHOUR,MIN,ISEC,IFLTR,NDAT,IHIPURGE
       READ(LUTAPE,40,END=3000)(IPOS(JA),JA=1,80)
       READ(LUTAPE,40,END=3000)(IREF(JA),JA=1,80)
       WRITE(LUW,40)(IPOS(JA),JA=1,80)
       WRITE(LUW,40)(IREF(JA),JA=1,80)
       DO 2000 IDATA = 1,NDAT
       READ(LUTAPE,400,END=3000)IALT,(DATA(JA),JA=1,6),ITIME
       WRITE(LUW,400)IALT,(DATA(JA),JA=1,6),ITIME
  400 FORMAT(1X,I4,1P6E11.4,I7)
 2000 CONTINUE
C
```

```
      READ(LUTAPE,400,END=3000)IALT,(DATA(JA),JA=1,6),ITIME
      WRITE(LUW,400)IALT,(DATA(JA),JA=1,6),ITIME
  400 FORMAT(1X,I4,1P6E11.4,I7)
 2000 CONTINUE
C
C       GO FOR NEXT FILTER
C
      GO TO 60
 3000 CONTINUE
      WRITE(LUW,4000)
 4000 FORMAT(1X,' END OF FILE ')
C
C       CLOSE INPUT FILE
C
      CLOSE(UNIT = LUTAPE,DISPOSE='SAVE')
      END
$
```

APPENDIX F

VISIBILITY LABORATORY CONTRACTS AND RELATED PUBLICATIONS

Previous Related Contracts:
F19628-81-K-0023, F19628-78-C-0280

PUBLICATIONS:

Duntley, S.Q., R.W. Johnson, J.I. Gordon, and A. R. Boileau, (1970) "Airborne Measurements of Optical Atmospheric Properties at Night", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 70-7, AFCRL-70-0137, NTIS No. AD 870 734.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1972a) "Airborne Measurements of Optical Atmospheric Properties in Southern Germany", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 72-64, AFCRL-72-0255, NTIS No. AD 747 490.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1972b) "Airborne and Ground-Based Measurements of Optical Atmospheric Properties in Central New Mexico", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 72-71, AFCRL-72-0461, NTIS No. AD 751 936.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1972c) "Airborne Measurements of Optical Atmospheric Properties, Summary and Review", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 72-82, AFCRL-72-0593, NTIS No. AD 754 898 (19'.2c).

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1973) "Airborne Measurements of Optical Atmospheric Properties in Southern Illinois", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 73-24, AFCRL-TR-73-0422, NTIS No. AD 774 597.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1974) "Airborne and Ground-Based Measurements of Optical Atmospheric Properties in Southern Illinois", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 74-25, AFCRL-TR-74-0298, NTIS No. ADA 013 164.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1975a) "Airborne Measurements of Optical Atmospheric Properties in Western Washington", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 75-24, AFCRL-TR-75-0414, NTIS No. ADA 026 036.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1975b) "Airborne Measurements of Optical Atmospheric Properties, Summary and Review II", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 75-26, AFCRL-TR-75-0457, NTIS No. ADA 022 675.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1976) "Airborne Measurements of Optical Atmospheric Properties in Northern Germany", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 76-17, AFGL-TR-76-0188, NTIS No. ADA 035 571.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1977) "Airborne Measurements of Atmospheric Volume Scattering Coefficients in Northern Europe, Spring 1976", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 77-8, AFGL-TR-77-0078, NTIS No. ADA 046 290.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1978a) "Airborne Measurements of Atmospheric Volume Scattering Coefficients in Northern Europe, Fall 1976", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 78-3, AFGL-TR-77-0239, NTIS No. ADA 057 144.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1978b) "Airborne Measurements of Atmospheric Volume Scattering Coefficients in Northern Europe, Summer 1977", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 78-28, AFGL-TR-78-0168, NTIS No. ADA 068 611.

Duntley, S.Q., R.W. Johnson, and J.I. Gordon, (1978c) "Airborne Measurements of Optical Atmospheric Properties, Summary and Review III", University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 79-5, AFGL-TR-78-0286, NTIS No. ADA 073 121.

Fitch, B.W. and T.S. Cress, (1981) "Measurements of Aerosol Size Distribution in the Lower Troposphere over Northern Europe", J. Appl. Met. **20**, No. 10, 1119-1128, also University of California, San Diego, Scripps Institution of Oceanography, Visibility Laboratory, SIO Ref. 81-18, AFGL-TR-80-0192, NTIS No. ADA 104 272.

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